Committee on Earth Observation Satellites

NASA Agency Perspective

David Crisp, Jet Propulsion Laboratory, California Institute of Technology

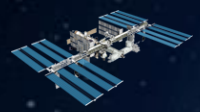
CEOS Chair Priority Workshop on GHG Monitoring

European Commission Joint Research Centre, Ispra, Italy

18-19 June 2018

Earth Science Current and Missions*

FY17 and Decadal Program of Record

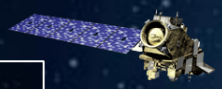


ISS Instruments

LIS, SAGE III
TSIS-1, OCO-3, ECOSTRESS, GEDI
CLARREO-PF

JPSS-2 Instruments

OMPS-Limb



- Formulation
- Implementation
- Primary Ops
- Extended Ops

Landsat 9

PACE

GeoCARB

TROPICS (6)

MAIA

Sentinel-6A/B

NI-SAR

SWOT

TEMPO

GRACE-FO (2)

ICESat-2

NISTAR, EPIC
(DSCOVR / NOAA)
(2019)

CYGNSS (8) (2019)

SMAP (>2022)

Landsat 7
(USGS) (~2022)

QuikSCAT
(2017)

SORCE,
TCTE (NOAA)
(2017)

Suomi NPP
(NOAA) (>2022)

Terra (>2021)

Landsat 8
(USGS) (>2022)

Aqua (>2022)

CloudSat (~2018)

CALIPSO (>2022)

GPM (>2022)

Aura (>2022)

OSTM/Jason-2
(NOAA) (>2022)

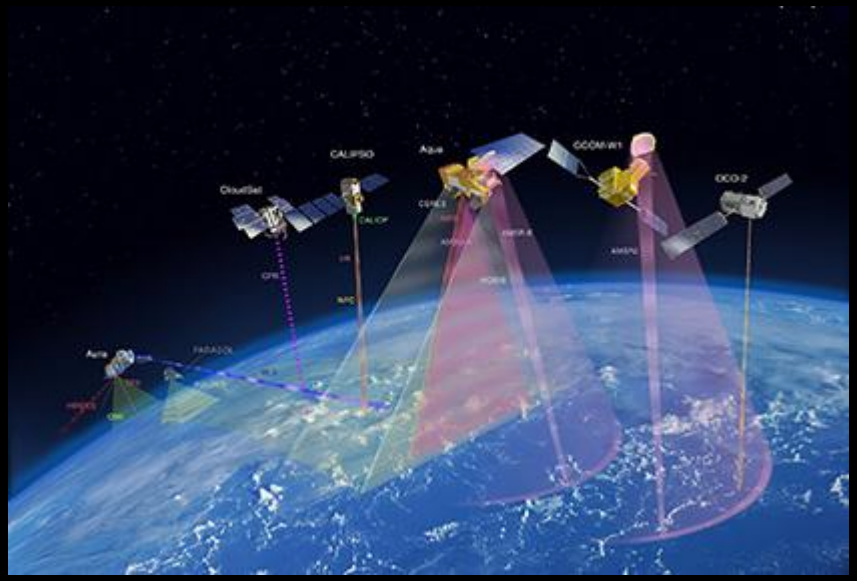
OCO-2 (>2022)

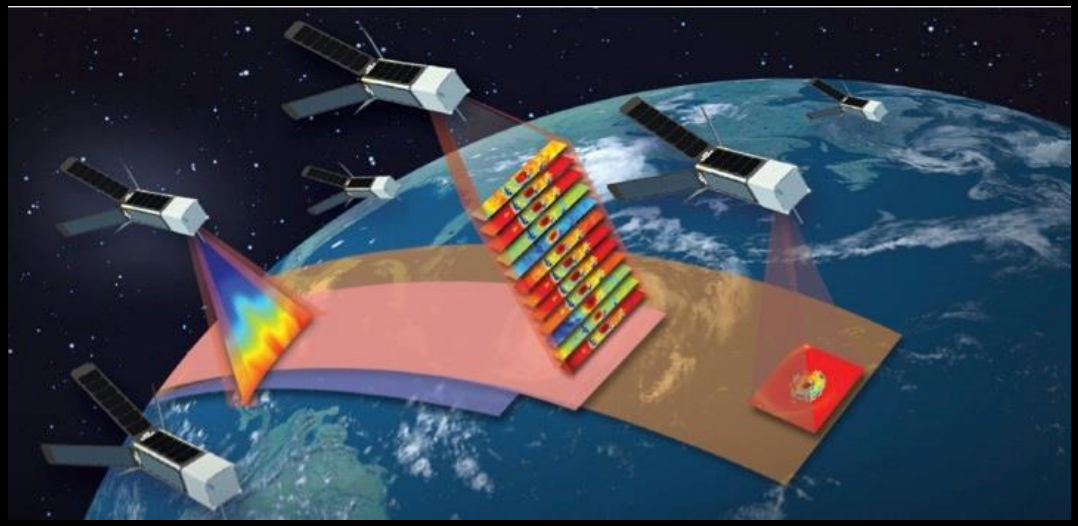
Invests/Cubesats

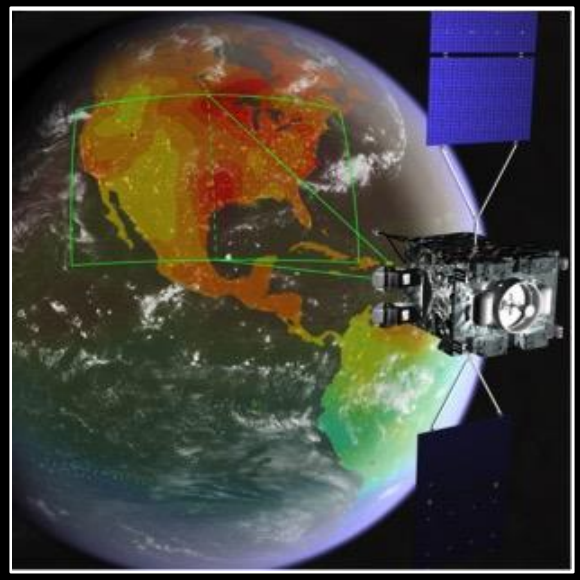
RAVAN	✓
IceCube	✓
MiRaTA	✓
HARP	
TEMPEST-D	
RainCube	
CubeRRT	
CIRiS	
~~CIRAS~~	
CSIM	
LMPC	

06.26.17

NASA Observing System Innovations







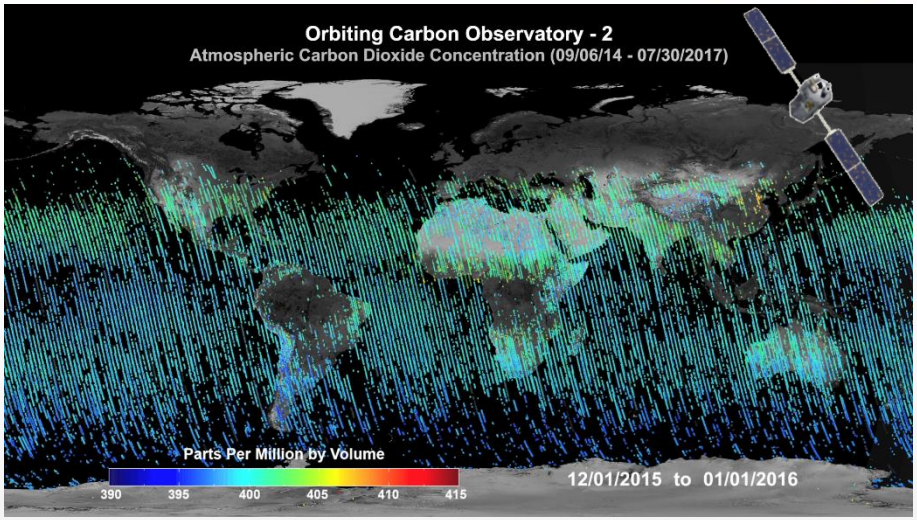
2017 Decadal Recommendations for Flight

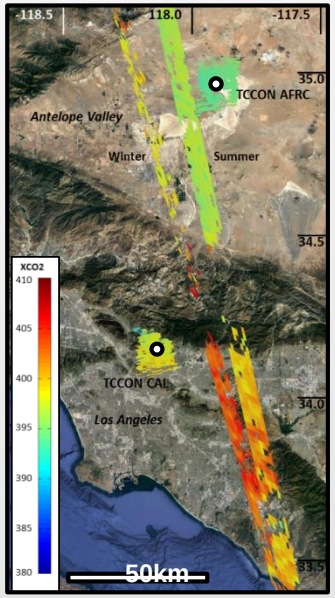
- Endorsed completion of Program of Record
- Encouraged portfolio integration rather than mission-specific solutions
- Identified 5 ”Designated” observables for mandatory acquisition (*Aerosols; Clouds, Convection, & Precipitation; Mass Change*; *Surface Biology & Geology; Surface Deformation & Change)* – all cost-constrained, not necessarily single-focus, all will likely have competed portions
- Introduced a new competed “Explorer” flight line with $350M cost constraint, 3 observables to be chosen by ESD from among 6 identified
- Recommended “Continuity Measurement” demonstration strand ($150M full mission cost constraint) for existing Venture-class program – first will be radiation budget to mitigate RBI cancellation, ~3 initiated within the decade
- Encouraged international partnerships
- Called for “Incubator Program” between Technology and Flight to mature specific technologies for important – but presently immature – measurements (preparation for next Decadal)
- NASA is exploring a full range of commercial/private sector partnerships – data buys, hosting, … .

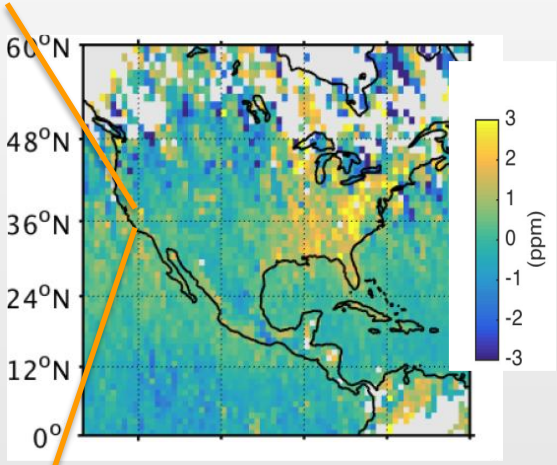
NASA Greenhouse Gas Program of Record

NASA Orbiting Carbon Observatory-2 (OCO-2)

- OCO-2 was launched in July 2014
- Since then, it has been collecting about one million soundings / day
- About 85000 of these are sufficiently cloud free to yield estimates of X_{CO2} with single sounding random errors near 0.5 ppm and regional scale biases < 1 ppm
- These data describe the CO_2 distribution with unprecedented resolution, and coverage
- These data have been used to study emission from compact sources (cities, power plants) the tropical carbon cycle response to the 2015-2016 El Niño

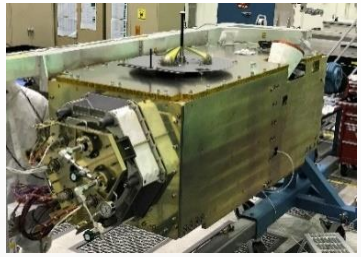


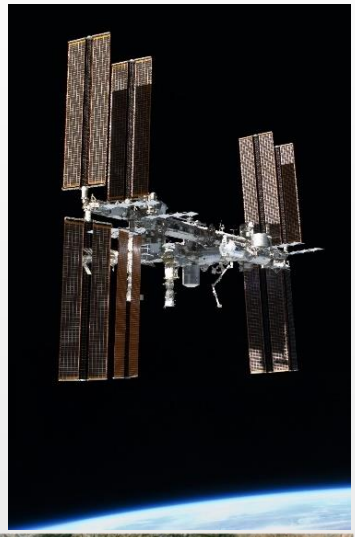




The NASA Orbiting Carbon Observatory-3 (OCO-3)

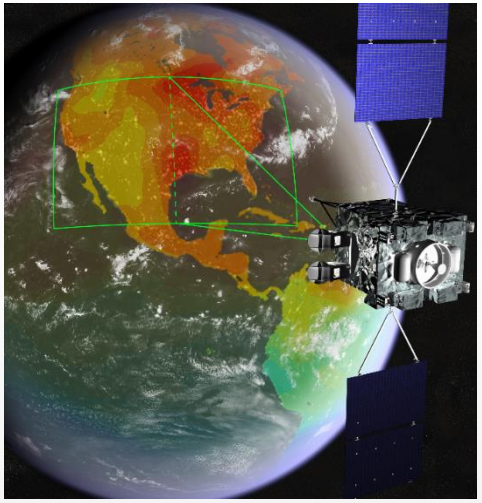
- In 2019, OCO-2 will be joined by OCO-3, which will be deployed on the Japanese Equipment Module Exposed Facility on the International Space Station, ISS
- OCO-3 integrates the OCO-2 flight spare spectrometers with an agile pointing mechanism.
- That pointing mechanism, combined with the low inclination orbit of the ISS will facilitate new types of investigations of CO_2 sources and sinks
  - acquisition of 100 km x 100 km “snapshots” of large urban areas and other targets
- OCO-3 has completed its pre-launch testing
- Once installed on the ISS, OCO-3 measurements will provide continuity for OCO-2 CO_2 and SIF data and provide new opportunities for studying the atmospheric carbon cycle

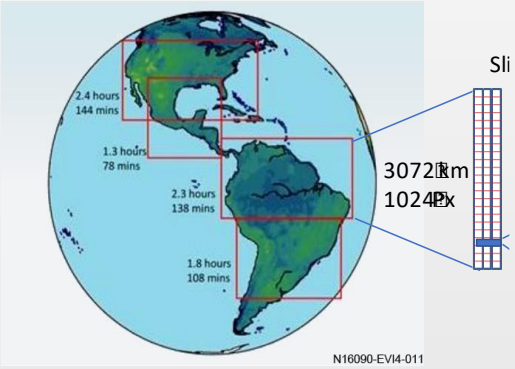




The NASA GeoCarb Mission*

- In December 2016, NASA selected the Geostationary Carbon Cycle Observatory (GeoCarb) as the second complete mission in the NASA Earth Ventures series.
- GeoCarb will be the first mission to acquire spatially resolved observations of greenhouse gases and solar induced chlorophyll fluorescence (SIF) at high spatial resolution (5 to 10 km) from geostationary orbit (GEO).
- GeoCarb will fly on a commercial communications satellite and carries an imaging grating spectrometer
  - O_2 (765 nm) CO_2, (1610 and 2060 nm), methane (CH_4) and carbon monoxide (CO; 2300 nm)
- It will launch in 2022 and be stationed between 75° and 100° West longitude in 2023.
- It will map these properties over North South America two or more times each day.





" Pre-Decisional Information -- For Planning and Discussion Purposes Only

Contributions from NASA Earth Science Data Analysis Programs

NASA's Earth Science Mission Operations & Data analysis and Research & Analysis Programs are also making critical contributions to GHG science

- Improved remote sensing retrieval algorithms for X_{CO2} and X_{CH4}
  - More accurate descriptions of gas absorption and aerosol scattering
  - Optimized to more fully exploit the information content of solar GHG spectra
- Support for vicarious calibration and validation
  - Vicarious calibration campaigns and solar and lunar standards
  - NASA's ground based TCCON validation sites
- Carbon Cycle Observing System Simulation Experiment (OSSE) initiative
  - Advanced modeling and data assimilation used in coordinated OSSEs to:
    - Assess/improve spatial resolution and accuracy of horizontal & vertical transport
    - Improve methods for assimilation of ground-based, aircraft, and space based data
    - Develop methods to validate fluxes on local, national, and regional scales
    - Assess performance requirements and observing strategies of GHG satellites
    - Improve understanding of CO_2 interannual variability through assimilation of biomass and atmospheric carbon (OCO-2, MOPITT) leveraging CMS-Flux